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THE
ONTARIO WATER RESOURCES
COMMISSION

REPORT ON

OBSERVATION WELL INSTALLATION

Districts of Cochrane & Thunder Bay

TD
412
.027
1969
MOE

C. G. Hamilton

1969

801 BAY STREET - TORONTO

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Observation well installation :
districts of Cochrane & Thunder
Bay / Hamilton, C.G.
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OBSERVATION WELL INSTALLATION

Districts of Cochrane & Thunder Bay

C. G. Hamilton

Ontario Water Resources Commission

1969

OBSERVATION WELL INSTALLATION

Districts of Cochrane & Thunder Bay

Introduction

During the early part of the spring of 1968, members of the staff of the Surveys & Projects Branch, Ontario Water Resources Commission, indicated that as an aid to their hydrogeological study of the Albany River drainage basin, it was desirable to establish observation wells within the basin. Consequently, in April and May of 1968, the writer together with Messrs. K.T. Wang and R. Wilkins of the Surveys & Projects Branch visited certain locations in the Albany River basin and the writer recommended three possible locations for the construction of these wells.

Unfortunately, prior to going in the field and while in the field, the writer was unaware that each member of the field party was expected to produce his own individual and secret report. There was to be no liaison between the members in the production of the report. Because this was not made clear before going into the field, the field work was organized so as to avoid duplication. Each party member examined a different area with the view of combining his observations where necessary so as to get a comprehensive preliminary report

on the surficial geology and accessibility of the area visited. Upon return to the office in Toronto, however, it was reported to the writer that orders had been issued to the other members of the party to withhold from him any information gathered in the field by them. Each person was to compile a separate and secret report without reference to one another's information. Up to the time of writing, the other reports are still not accessible to the writer. With these restrictions, the writer produced a report recommending three possible sites for observation well installations.

During November and December of 1968, observation wells were installed in two of the areas: the Hanover Lake-O'Sullivan Lake area, District of Thunder Bay; and the Rogers Creek-Kabinakagami area, District of Cochrane.

Towards the middle of November, a two man drilling crew using a D.R. Franks rotary drill, commenced to install the wells in the District of Thunder Bay. The weather was continuously below freezing with light snow on the ground when operations commenced. By the time the work was completed in this area, over two feet of snow had accumulated, and during the last week, temperatures were frequently below zero. In the District of Cochrane,

work started on the two wells installed there on December 6 and terminated on December 18. Temperatures in the area at this time ranged from a few degrees above zero to 30 degrees below.

The drilling sites were cleared by the writer with the aid of one or two casual labourers, and access roads constructed. Pits for mixing and containing drilling mud were dug at each site by the writer prior to the setting up of the drill rig on the site. Each pit was dug four feet deep and in such a manner that the bottom of the pit was four feet square. Levels were also taken by the writer over the area where the first three wells were drilled; but these elevations were not related to any known benchmarks or datum in the area. The relative elevations of the collar of the other wells have not been determined.

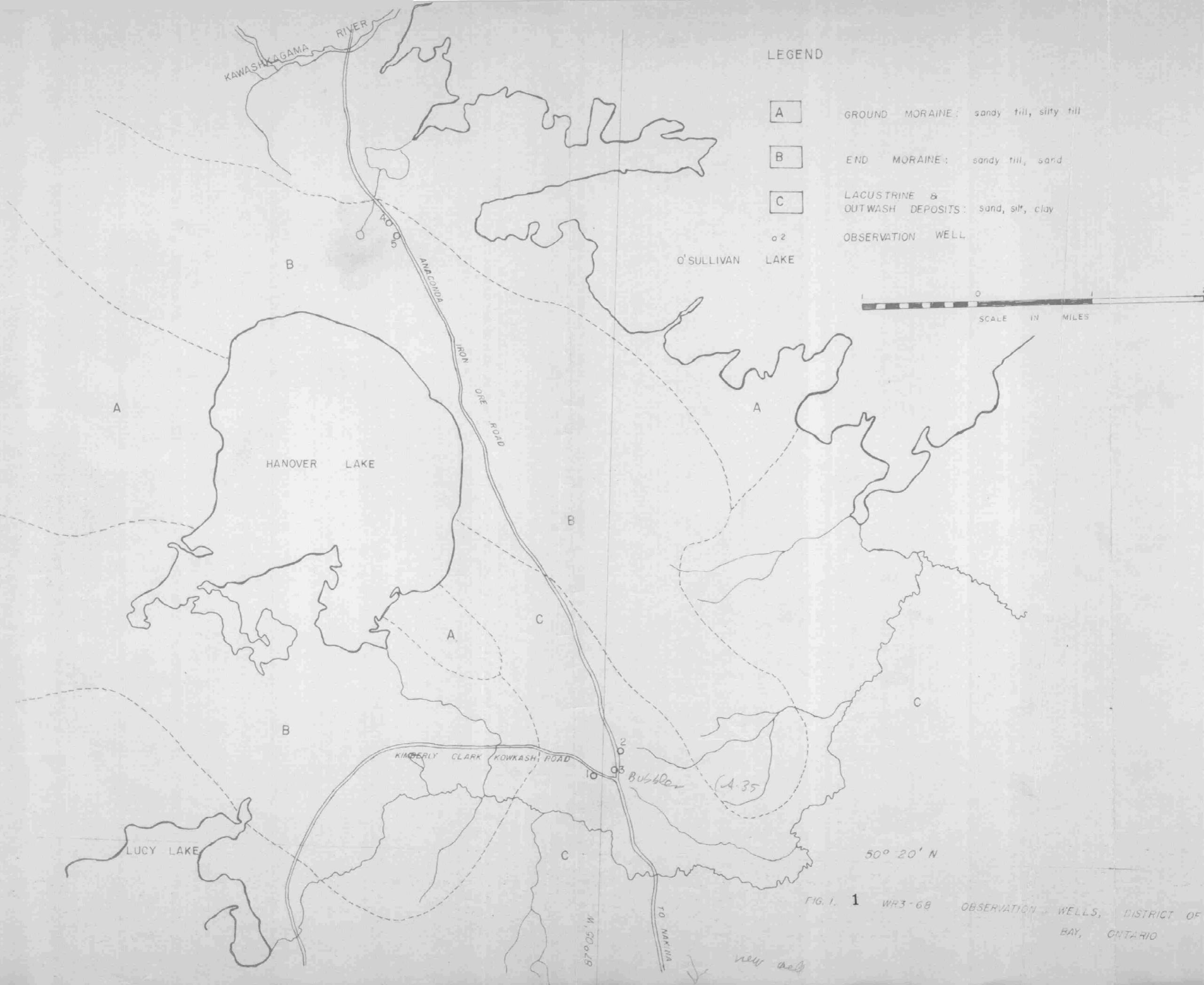
Lack of adequate maps and aerial photographs of the areas where the wells are located was profoundly felt.

WELL INSTALLATION

District of Thunder Bay

Five wells were drilled in the District of Thunder Bay. Three of the wells are located near the intersection of the Anaconda Iron Ore and the Kimberly Clark Kowkash roads (Fig. 1), to the southeast of Hanover Lake in Rupert Township. The other two wells are located on the west side of the Anaconda Iron Ore Road north of Hanover Lake. The wells at the former location are designated 1, 2 and 3, and at the latter location, 4 and 5. Both locations are accessible via the Anaconda Iron Ore Road, which is a private road forming a continuation to the northern end of Highway 643. There is unrestricted travel over the part of the Anaconda Iron Ore Road between the wells and Highway 643. Wells 4 and 5 are approximately $1\frac{1}{2}$ miles to the south of where the Anaconda Iron Ore Road crosses the Kawashkagama River (Fig. 1). A stream gauging station is maintained near this location.

The wells are located in the Agutua moraine complex. This moraine is several miles in extent and transects or intersects the Severn, Winisk, Attawapiskat and Albany River basins. Wells 1, 2, and 3 are located on the south side of the moraine in lacustrine deposits



associated with proglacial lakes/lake which formed in front of the ice. Figure 2 shows sections through the lacustrine deposits as well as the piezometer configurations in each hole. Wells 1 and 2 are each 1,000 feet from well 3. All are collared in well sorted medium brown fine grained lacustrine sands underlain by clay which is underlain by well sorted silt. All three wells have been terminated at the bedrock interface. The bedrock is "greenstone". Wells 1 and 3 transect sandy till or silty till which overlies the "greenstone".

After each well was drilled, the hole was washed out by circulating water through it. By doing this, much of (but not all of) the mud adhering to the walls of the wells is dislodged and removed from the hole. Mud which had penetrated into the formations adjacent to the hole as well as some of the mud in the hole itself, is not washed out. To get rid of this remaining mud, the wells are developed by pumping.

Attempts to develop each well met with varying degrees of success. The upper and lower piezometers in well 2 were pumped intermittently for over 6 hours. No clear water was obtained. The water yield from the well was so low that the water available for pumping in both piezometers would be depleted after 20 to 30 seconds of pumping. Thereafter the clay or silt

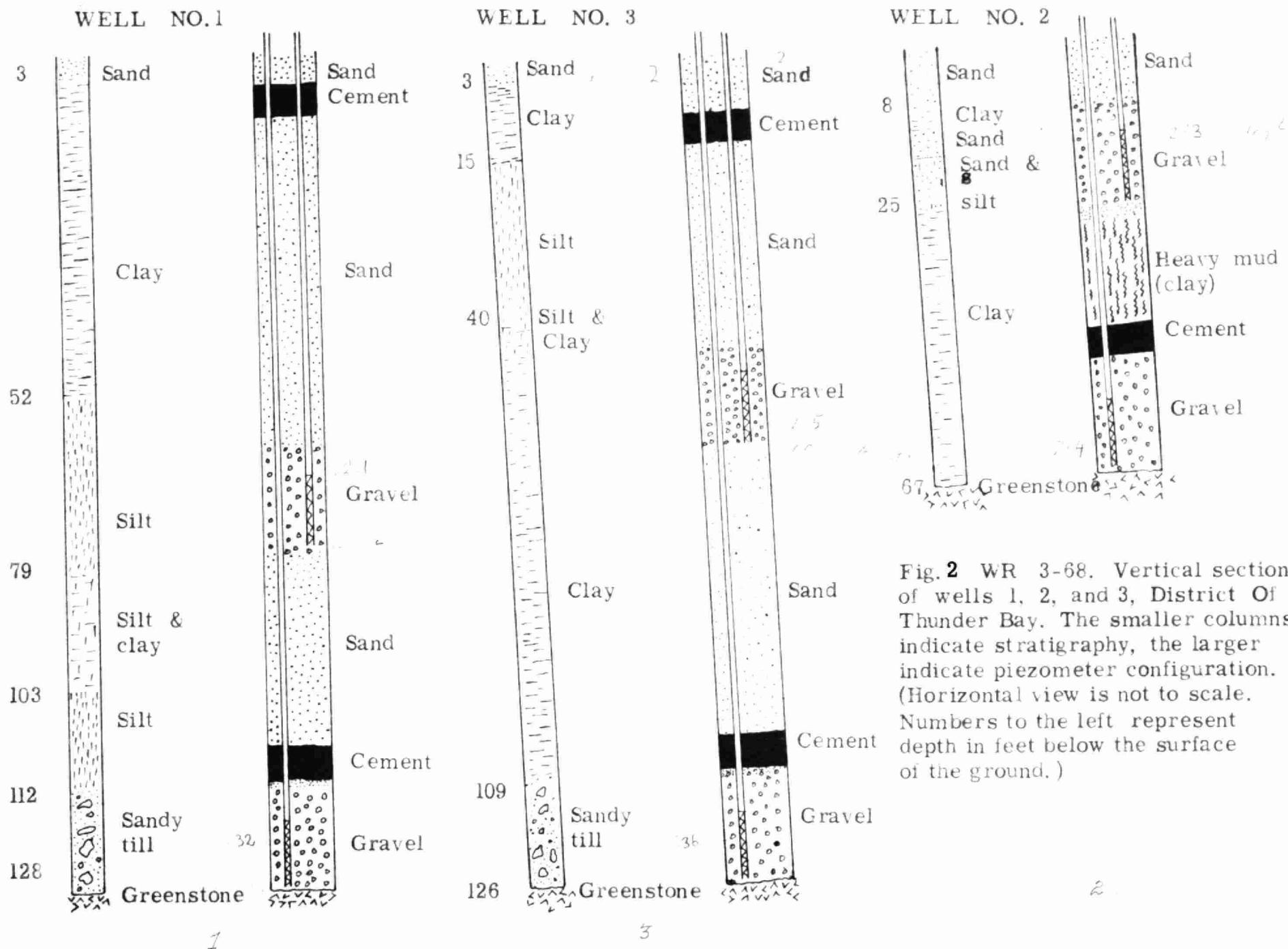


Fig. 2 WR 3-68. Vertical sections of wells 1, 2, and 3, District Of Thunder Bay. The smaller columns indicate stratigraphy, the larger indicate piezometer configuration. (Horizontal view is not to scale. Numbers to the left represent depth in feet below the surface of the ground.)

which comprise the surrounding deposits would invade the piezometer tube and be pumped out. For this reason, each piezometer was pumped intermittently. Pumping was done for two to three minutes and then the pump was shut off for 15 to 20 minutes. Neither piezometer yielded clear water and pumping was discontinued when the yield of clay and silt became excessive because it was feared the screens might become plugged from the invading material.

Slotted 1½-inch* pipe was used in well 2. Washed and screened 5/16-inch pebble gravel was packed around and approximately five feet above the screen, which was made from slotted wrought iron casing. Each screen is 11 feet long. The purpose of the gravel is to keep the clay and silt back from clogging the screen.

Well 2 was the first of the wells to be constructed. Based on the experiences gained from it, with the invasion of clay and silt from the surrounding formation, a slight modification to the screen was made in the other holes. Fine nylon fly netting of the type used for fly screens in dwellings, was used to wrap the slotted screens. The netting was secured to the casing by clamps.

After pumping the lower piezometer in well 1

* In this report, pipes are referred to by their inside diameter.

for approximately $\frac{1}{2}$ hour, the water discharged appeared to contain exceedingly small quantities of clay, but would not become clear because pale grey silt and very fine sand was being discharged from the well. The material being discharged is similar to that comprising the matrix of the till (Fig. 2). The upper piezometer was pumped for eight minutes when silt began to appear in the effluent. Pumping continued for another seven minutes without any noticeable decrease in the volume of water being discharged, but with a marked increase in the amount of silt being discharged. Pumping was discontinued for 20 minutes, after which it was resumed. The previous conditions prevailed and so further development of this piezometer was discontinued. At the time pumping was terminated, the water being discharged still contained much silt and clay. It is not known whether this clay is from the surrounding formation or if it is part of the clay introduced in the well as drilling mud.

The upper piezometer of well 3 behaved similar to those in well 1. Therefore, much clay was also incorporated in the sample taken from this piezometer. In the lower piezometer, most of the clay was probably discharged by pumping, but much silt remained in the effluent. A pumping test was carried out on well 3, pumping from the

lower piezometer. Pumping was carried out for two hours and a total of 40 gallons of water and silt was pumped from the well. This represents a pumping rate of 0.33 gallons per minute. The well did not appear capable of a much greater yield. Measurements during the test were taken in well 1 but no noticeable effect was observed. Attempts to measure recovery on the pumped well were abortive.

The temperature at the start of the test was a few degrees below zero. The pumping device used for the test is compressed air, which blows the water up the well casing. Attempts to measure the drawdown and recovery were unsuccessful because:

- (1) The walls of the well casing were wet and this wetted the tape in various places. Consequently, it was impossible to determine the exact wet mark due to the water level in the well.
- (2) The tape had to be pulled up with much haste in order to get a reading at the required time. By pulling the tape back, the water on it froze almost immediately contact was made with the surrounding air. The ice could only be removed with difficulty from the tape; and if it were not removed, when the apparently dry tape was chalked and

lowered into the well again, the ice melted upon getting in contact with the warmer air in the well. Consequently, the tape became wet in various places in addition to those which may have had direct contact with the walls of the well casing or the well water; rendering proper water level determination impossible to obtain.

(3) Upon encountering these difficulties and making repeated attempts to get a proper water level reading, a reliable reading was obtained after 15 minutes had elapsed. The writer realized that further measurements would be meaningless and discontinued the attempts. The critical first 10 minutes of recovery time were lost.

Well 4 (Fig. 3) was then drilled following the completion of wells 1, 2 and 3. This well was drilled to 30 feet through sands and sandy till or regolith resembling sandy till. The hole was terminated at the "greenstone" bedrock interface, but yielded no water. Well 5 (Fig. 3) is 760 feet from well 4 in the direction 160° (magnetic). It is almost 42 feet deep and although the static level was not determined after pumping to develop the well, the resistivity logs (Appendix A) indicate that the static level may be expected at approximately 35 feet. Two lengths of 2-inch pipes were installed in

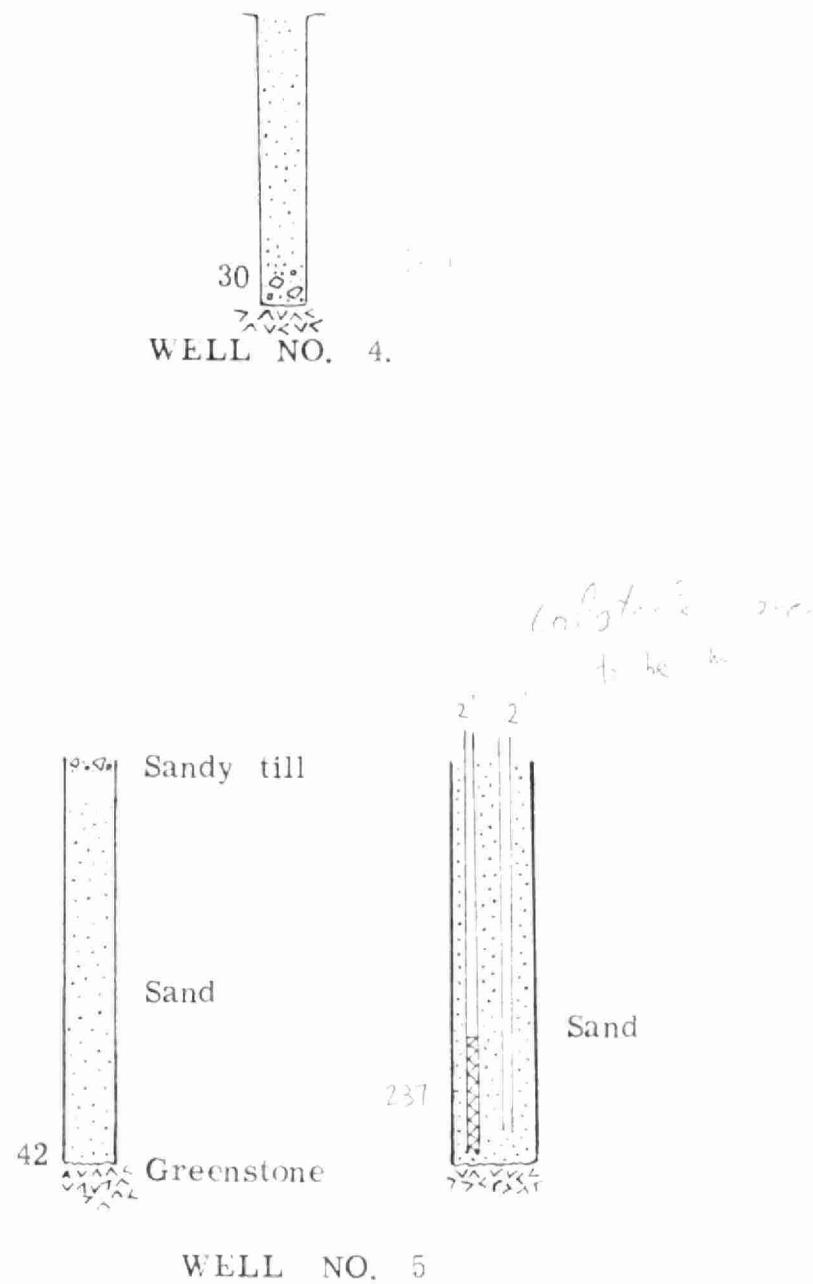


Fig. 3 Vertical sections through wells 4 and 5, District Of Thunder Bay. Legend is similar to that in figure

the well so that it could be fitted with a recorder in the future. One length of pipe was set below 41 feet with an 11-foot slotted screen at the lower end. The other, an open end pipe with a bit of nylon screen clamped to the lower end, is set at 39 feet. The part of the hole around the 11-foot screen was backfilled with coarse grained and very coarse grained sand derived from the mud pit. The upper part was filled with finer material from the same source. The backfill was as similar to the original material as could be estimated. After setting the pipes, the hole was pumped for $2\frac{1}{2}$ hours at approximately four gallons per minute. Brown muddy water ceased to be discharged after approximately $\frac{1}{2}$ hour of pumping, but slightly discoloured water continued to flow from the well. At the end of pumping, the water was cloudy.

The drillers explained that the low pumping rate of approximately four gallons per minute bears no relationship to the specific capacity of the well because of insufficient submergence. The length of pipe submerged in the water of the well was insufficient to produce a greater discharge under the prevailing conditions.

Wells 4 and 5 are located in the northern slope of the Agutua moraine complex. The moraine in this location

has been the result of the action of ice and water, so that there is some small degree of sorting and poorly developed layering in the morainic material.

Logs for wells 1-5 are included in Appendix B. Wells 3 and 5 have two two-inch diameter pipes in them so that they may be fitted with automatic recorders. All the other wells have 1½-inch pipe and must be measured manually. Table 1 shows water level measurements taken in wells 1, 2 and 3 between November 20 and 28, 1968.

The water samples collected from well 2, and the upper piezometers of wells 1 and 3 are not wholly reliable samples because there was an insufficient volume of water yielded to the well to enable foreign material introduced by the drilling mud and the backfilling media to be washed out while developing the holes. The water samples were turbid, and their apparent colour units were high, (in excess of 30), where they could be determined. These samples also contained the highest concentrations of chloride and iron (Table 2 a,c) up to 221 ppm Fe in the lower piezometer of well 2; and up to 81 ppm chloride in the lower piezometer of well 1. In addition, these samples also had the highest pH and consequently, the highest quantity of dissolved solids. The holes or piezometers which yielded greater volumes of

TABLE 1

Well Number	Measuring Time		Piezometer Reading (Static Level) In Feet	
	AM/PM	Nov. 1968	Upper	Lower
1	12.30*	20	49.12	50.92
	9.45	22	48.96	51.38
	10.00	23	49.09	48.35
	8.50	24	48.99	48.00
	10.25	25	49.25	47.93
	10.05	26	49.18	47.91
2	10.00	20	21.37	38.19
	9.30	22	21.03	37.03
	9.50	23	22.27	36.54
	8.30	24	22.49	36.14
	11.00	25	22.57	35.64
	10.45	26	22.90	35.30
3	9.45	24	31.36	70.23
	10.00	25	30.88	71.28
	10.30	26	30.38	71.23
	9.30	27	30.18	71.23
	10.00	28	30.14	71.34

* All readings were taken in the A.M.
with the exception of the first.

TABLE 1 Static levels in 3 wells in the
Hanover Lake-O'Sullivan Lake
area, District of Thunder Bay.

TABLE 2
(All analyses except pH are reported in ppm, except indicated otherwise)

Lab. No.	Hardness as CaCO ₃	Alkalinity as CaCO ₃	Iron as Fe	pH at Lab.	Apparent Colour Units	Chloride as Cl	Alkalinity		Field No.
							Carb.	Bicarb.	
W10015	236	206	0.61	8.3	< 5	2	0	206	1
W10016	182	221	0.45	8.7	**	8	22	191	1L
W10017	*	256	70.5	9.7	Too dark	81	-	-	1U

(a)

Lab. No.	Sodium as Na	Sulphate as SO ₄	Calcium as Ca	Potassium as K	Magnesium as Mg	Total Dissolved Solids	Conductivity in micromhos/CM ³
W10015	10.0	12	62	1.7	19	280	454
W10016	79	17	41	3.7	19	320	530
W10017	135	+73	-	15.3	-	740	675

(b)

* Result is spurious because sample was not filtered

** Sample exhausted

+ Sample acidified and filtered

W10015: Well 1, Kabinakagami-Rogers Creek area.

W10016: Lower piezometer of well 1, Hanover Lake-O'Sullivan Lake area.

W10017: Upper piezometer of well 1, Hanover Lake-O'Sullivan Lake area.

TABLE 2 Analyses of water samples from wells in the districts of Thunder Bay and Cochrane.

(Continued)

TABLE 2 (Continued)

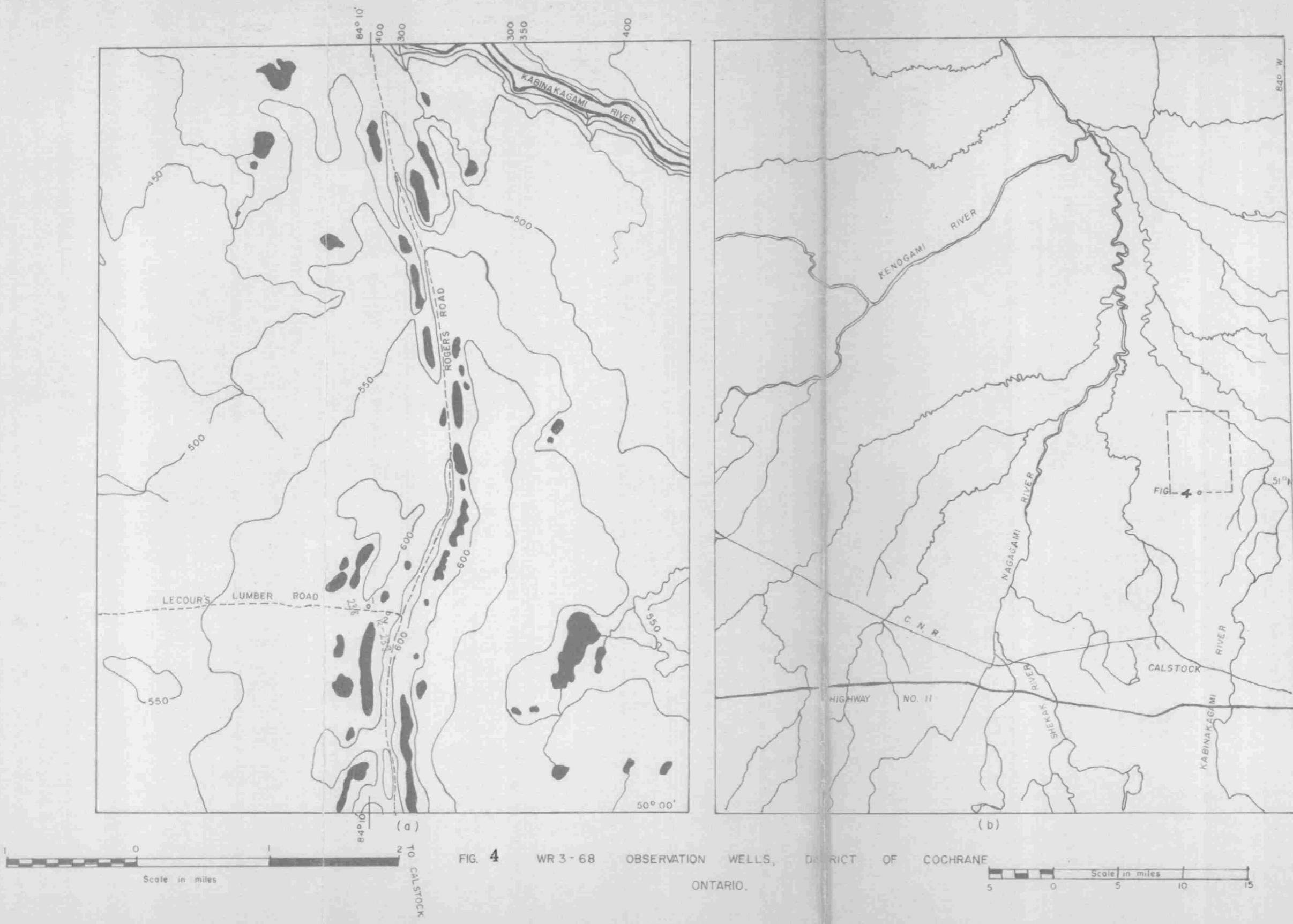
(All analyses except pH are reported in ppm, except indicated otherwise)

Lab. No.	Hardness as CaCO ₃	Alkalinity as CaCO ₃	Iron as Fe	pH at Lab.	Apparent Colour Units	Chloride as Cl	Sulphate as SO ₄	Total Dissolved Solids	Conductivity in micromhos/CM ³	Field No.
W10018	224	*	0.56	8.6	30	2	14	240	473	2
W10019	*	**	221	8.5	**	14		350	507	2L
W10020	*	**	105	9.1	**	18	+45	3200	369	2U
W10021	196	291	1.32	8.6	50	7	30	360	567	3L
W10022	*	517	1.50	9.6	-	50	+73	2400	435	3U
W10023	188	183	0.94	8.6	30	1	8	160	357	5

(c)

* Sample unfiltered
** Sample exhausted
+ Sample acidified and filtered

W10018: Well 2, Kabinakagami-Rogers Creek area.
W10019: Lower and upper piezometers of well 2, Hanover Lake-O'Sullivan Lake area.
W10020: O'Sullivan Lake area.
W10021: Lower and upper piezometers of well 3, Hanover Lake-O'Sullivan Lake area.
W10022: O'Sullivan Lake area.
W10023: Well 5, Hanover Lake-O'Sullivan Lake area.



water, thus extricated greater quantities of substances introduced into the wells, and produced water quality results significantly different from those with very small yields. The drilling mud and/or the surrounding clay therefore have had a pronounced effect on the quality of the water.

Samples of overburden were taken of most of the formations transected, but not in the tills. The drillers contend that this could not be done due to the rocky nature of the material. Because of pebbles and boulders in the till, the rate of penetration in till was about one-fifth to one-tenth of that in clay, silt or sand. These pebbles and boulders prevent the penetration of the core barrel into the overburden and thus impede the recovery of an undisturbed sample.

District of Cochrane

Two wells (Fig. 4) were installed in the Kabinakagami-Rogers Creek area, 18 miles north of Calstock in the District of Cochrane. Both wells are located near the intersection of the Lecours Lumber Camp road and the Rogers Road - a public forest road built and maintained by the Ontario Department of Lands and Forests.

The well sites are in township 332 approximately 21 miles from Highway No. 11. It had been planned to establish these wells near the Polar Lumber Camp approximately $1\frac{1}{2}$ miles from their present location; but at the time the wells were drilled, there was in excess of three feet of snow on the ground; the Polar Lumber Camp had been abandoned and the road to it was not easily accessible. At the present location, the surface appears geologically similar to the site originally chosen.

Sections through the overburden of the area are shown in figures 5 and 6. The area is a relatively flat plain overlain by a blanket deposit of clayey till. Well 1 penetrated the entire cover of overburden and terminated at the limestone bedrock interface. The clayey till is underlain by sands and pebble gravels. Both the sands and the gravels are very porous.

Because of the contamination suspected from the use of drilling mud in the District of Thunder Bay, an attempt was made to drill these holes without drilling mud. No difficulties were encountered until at a depth of over 30 feet in well 1, a noticeable loss of circulation of water began to take place. The loss of water increased rapidly and directly with the depth of the well, so that close to 100 feet, nearly 600 gallons of water would be lost to the formation in less than 10 minutes.

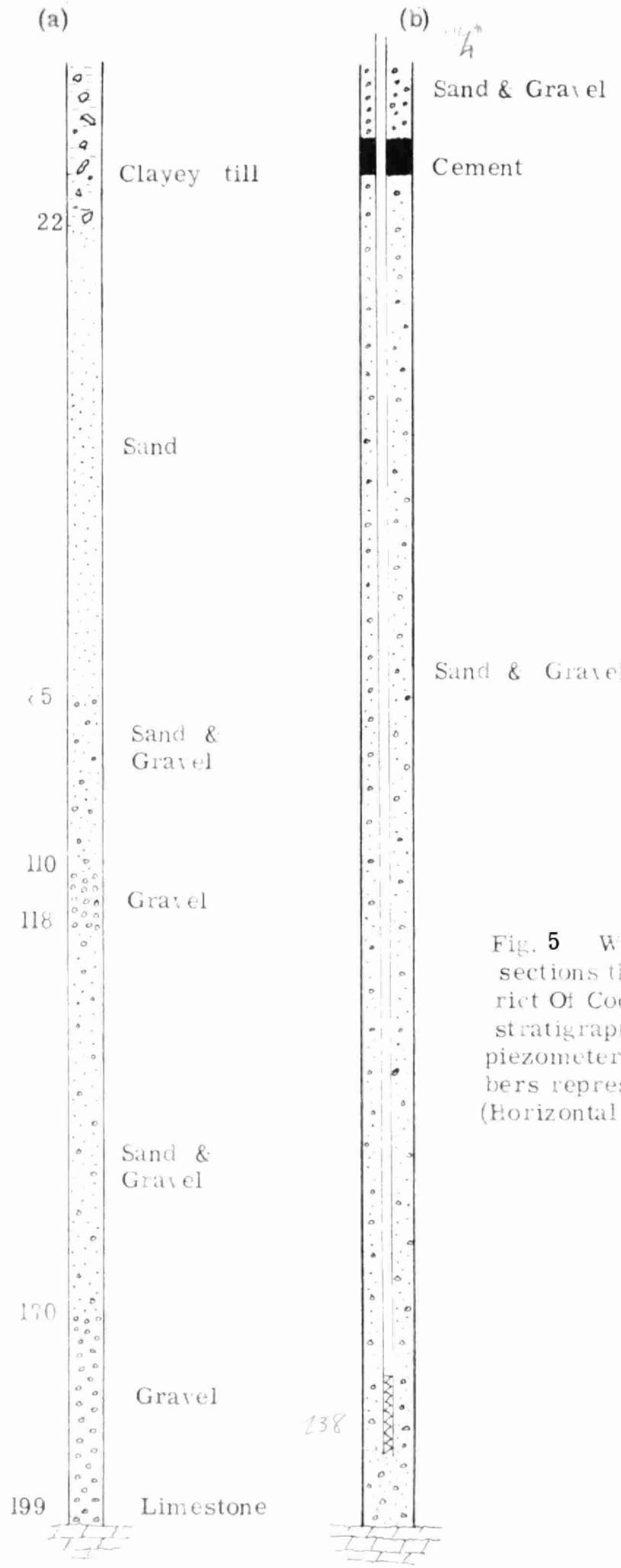


Fig. 5 WR 3-68. Vertical sections through well 1, District of Cochrane. (i) indicates stratigraphy, (ii) indicates piezometer configuration. Numbers represent depth in feet. (Horizontal view is not to scale).

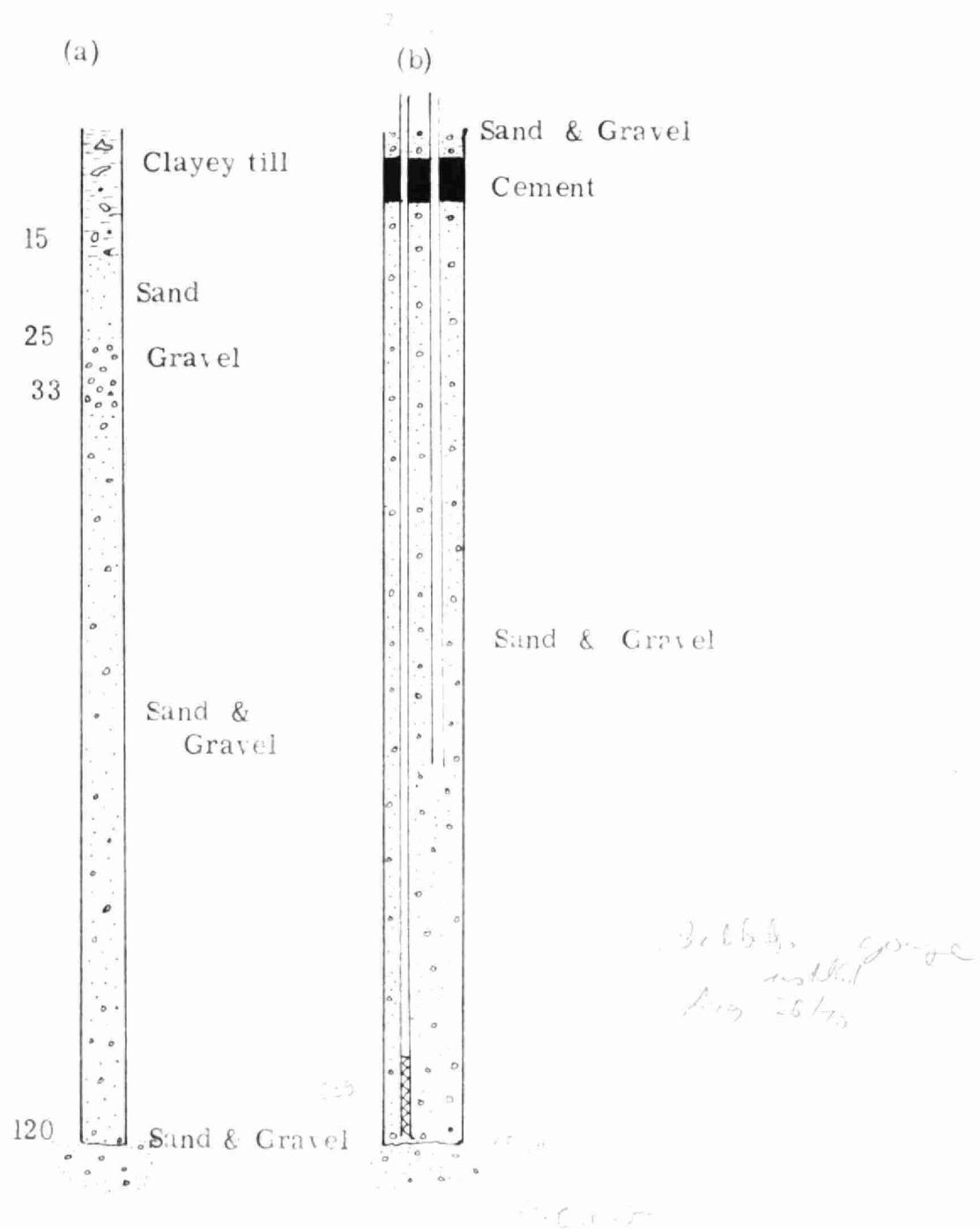


Fig. 6 WR 3-68. Vertical sections through well 2, District Of Cochrane. (a) Stratigraphic section (b) Piezometer configuration. Numbers indicate depth in feet. (Horizontal view is not to scale.)

Consequently, below 100 feet drilling mud was used.

With the introduction of drilling mud, a smaller volume of drilling fluid was lost over a given period, but the loss was yet very critical. As the hole became deeper and encountered more gravels, the mud loss became progressively more intense, and a stage was reached where even though the mud was at the maximum viscosity for drilling, almost 600 gallons would be depleted in 15 minutes. These problems were encountered between the depth 110 and 170 feet. Each time drilling was stopped in order to fetch additional water, or at the end of a day, there was a loss of footage in the hole due either to caving in of the walls or settling out of suspended particles not carried out of the hole by the drilling mud. At one stage, between 170 and 185 feet, the material in the hole was such coarse pebble that even though a very viscous mud was used, over 300 gallons of it were depleted without any significant gain in depth. At 185 feet, three hours of drilling using several hundred gallons of mud produced less than one foot of advance in the hole.

Under these conditions, 199 feet of hole were drilled in four days giving an average advance of 46 feet per day. This compares with an average advance of 79 feet per day in the District of Thunder Bay.

Originally, it had been planned to drill well 1 through the Paleozoic bedrock to the Precambrian basement in order to determine the water potential in the Paleozoic rocks. However, after encountering the gravels, the drillers reported that this could not be done because if there were a cave-in of the overburden while drilling in the bedrock, the drilling rods and bit would most likely become stuck and could only be retrieved with considerable difficulty and expense. Consequently, this part of the programme had to be abandoned.

The well was then fitted with a piezometer (using 1½-inch pipe), the configuration of which is shown in Figure 5. The pipe was set in the hole with a slotted screen 11 feet long at the lower end. By the time the length of pipe was fitted and lowered to the bottom of the hole, ten feet of cave-in or settling out of material from the drilling mud had occurred, so that there was a loss of ten feet in the hole. The pipes were therefore set at 189 feet and not at 199 feet. The pipe was set and left overnight. By the following day, the entire length of the screen had been buried from further cave-ins in the hole.

A second hole, well 2, was started in a direction approximately 115° (magnetic) and 800 feet from well 1. Geological logs for this well is included in Appendix B. The hole was drilled to a depth of 120 feet and terminated

because of the depletion of allocated funds. It transected 15 feet of clayey till followed by 10 feet of very coarse grained poorly sorted medium brown sand underlain by a very coarse grained pebble gravel which rests upon poorly sorted pebble gravel mixed with or intercalated with sand.

The problems encountered in drilling this hole were similar to those encountered in drilling well 1, but more difficult. There was a greater accumulation of snow on the ground, the temperature lower, and stayed below -15°F most of the time. The permeable nature of the sand and gravel caused a more rapid loss of drilling mud. On the whole, the gravel was coarser than that in well 1, and the drilling operation consumed even more water per foot of drilling. The progress was therefore slower than in the previous hole. A total of seven days was spent in constructing the well, six of which were spent in drilling and attempting to drill. Since the hole was 120 feet deep, the average advance on the hole was 20 feet per day, or less than half what it was for the previous hole.

At the commencement of drilling, drilling mud was not used, but mud had to be used soon after the clayey till horizon was penetrated because of very rapid loss of water.

Two lengths of 2-inch diameter pipe were installed in the well. One length with a screen at the lower end was set at 120 feet and the other without a screen was set at 76 feet. The well was then backfilled with sand and gravel and a cement plug put in near the top within the clayey till horizon. The well was pumped for four hours at a rate of approximately six gallons per minute. Because of insufficient compressor capacity and the size of the air line, the rate of pumping or the discharge from the well bears little or no relationship to the specific capacity or potential yield of the well. Although several thousand gallons of drilling mud had pervaded the walls of the well, only slightly cloudy water was obtained after pumping for four hours. The apparent colour index of the sample taken at this time is 30 units (Table 2).

Core samples were not taken from the aquifer because of problems similar to those in sampling sandy till.

The speed with which the water in both wells 1 and 2 cleared up, that is became free of drilling mud, is an indication of the large volume of water that may be available and the high transmissibility of the sediments. After developing well 1 for 8 hours, the water was colourless and the sample collected had an apparent colour index

of less than five units.

Clay either from drilling mud or from the formations intersected have induced a certain amount of hydrogen iron concentration in the wells. Samples with the highest pH also tend to have the highest colour index, iron and chloride content, as well as total dissolved solids. Consequently, the wells in the District of Cochrane, because they yielded more water, the waters collected were of better quality than those in the District of Thunder Bay. Well 5, District of Thunder Bay, is an exception. This well did not intersect any clay horizons and it had a good yield of water.

CONCLUSION AND RECOMMENDATIONS

Construction of the wells in the districts of Thunder Bay and Cochrane has been completed but for the installation of recorders, and the designation of the wells. No data will be available from the wells during the present winter. The three wells with 2-inch pipe should be equipped with recorders during the spring or summer.

Samples have been collected from most formations transected. These samples should be tested for

porosity and permeability in order to furnish additional information concerning the hydrogeological properties of the formations samples.

Indications are that the water yield from the wells in the districts of Thunder Bay and Cochrane will be low and high, respectively. Where practical, slug tests should be conducted during the summer to determine permeability and transmissibility of some of the formations.

In the District of Cochrane, a large diameter well should be drilled and a regular pumping test carried out if these factors are to be determined. Permeability and transmissibility of the aquifer as well as the overlying sands are too high to produce satisfactory slug tests. If a pumping test is to be carried out, a pump capable of pumping 150 to 200 gallons per minute should probably be used.

Low temperatures produced many problems and necessitated many hours of extra work. Freezing up of the drilling rig, difficulties in starting the drill, freezing of the water tank and the mud pump are some of the difficulties encountered. Each of these took $\frac{1}{2}$ to 2 hours to get thawed and back into working condition. Each time the rig was shut down for the drillers to get water, hoses and pipes had to be disassembled, drained and reassembled, necessitating 20 to 30 minutes of work. This had to be done at the end of each shift also. In

the District of Cochrane and average of over three trips were made each day to get water. Each trip took one to 1½ hours. In an eight-hour working day, at least five hours were spent each day in getting water, draining pipes and hoses, etc. To save time in draining pipes and hoses, the pump was left running on one occasion so that the mud would keep circulating and not freeze. However, this was unsuccessful as the mud froze in one of the drill stems. Using blow torches, it took almost two hours to dislodge the ice from the drill stem, and get the mud flowing again.

In addition, all the gravel pits in the neighbourhood were closed or inaccessible because of snow and ice. Consequently, at both drilling localities, gravel had to be hauled for over 60 miles at a rate of \$1.00 per mile for transportation, excluding the cost of the gravel. Had the weather been warm, it would have been possible to screen and haul gravel from pits within five miles of the drilling localities. Also, material from the holes themselves would not have been frozen and could be used for backfill.

Consequently, the writer would recommend that observation well installations in northern Ontario be done late in the summer or early in the fall. This would eliminate the cold weather problems encountered and effect

some savings in the programme. This would probably be of the magnitude of 15 per cent to 20 per cent of the total cost of the programme excluding mobilization. Also, if provision and facilities were made to service the drilling crew with water, gasoline, gravel, etc., a reduction of 50 to 80 per cent of the total time spent on the project by the drillers could be achieved. Unskilled labour could be hired at \$2.00 or \$2.50 per hour to fetch water, gravel, pipes, gasoline, etc., instead of paying \$35.00 per hour for the drillers to do these tasks. Pits for drilling mud were dug by the project geologist who was paid less than \$3.17 per hour. Had the drillers dug these pits themselves, the pits would have been dug at \$35.00 per hour. Drillers should be used solely to operate the drilling equipment including the installation of pipes, and cheap labour such as ~~geologists and engineers~~ used for the various other miscellaneous jobs.

Water samples were collected from each well and piezometer which produced water. All the tests requested from the laboratory were not performed because some of the samples were exhausted. In future, each sample collected for analysis should be two bottles of water (approximately 80 ounces).

Since drilling mud is suspected of causing well

contamination, rotary drilling should not be undertaken if good and reliable water quality results are desired.

In order to have good correlation of the wells with the lakes and streams in the neighbourhood, the elevations of the well collars should be determined and tied in to known benchmarks and other water level determinations in the area.

OBSERVATION WELL INSTALLATION

Districts of Cochrane & Thunder Bay

APPENDIX A

(Resistivity Logs of Observation Wells)

DRILLERS LOG

H. PETERMAN
6" ROTARY

BOG

SAND

BROWN CLAY

BLUE & GRAY CLAY

SILT STREAKS.

SILT, CLAY

SILT, CLAY

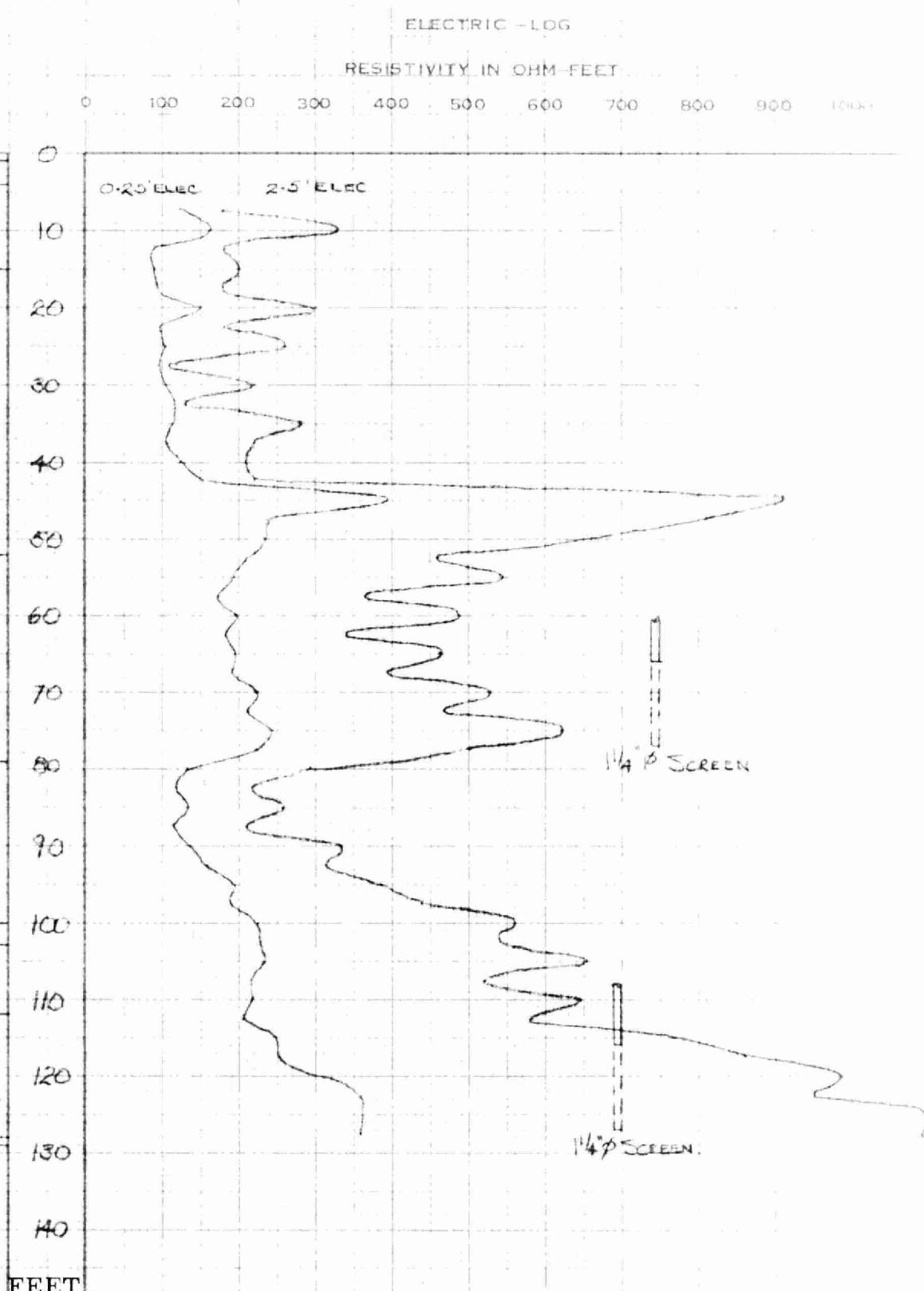
SILT

SILT, CLAY

CLAY, GRAVEL

SAND, BOULDERS

ROCK



Appendix A.

Electric log of well 1, Hanover Lake-O'Sullivan Lake area
District of Thunder Bay. Static level is at 49.12 feet.

OWRC. O'SULLIVAN LAKE
LOG NO. TESTWELL
2168
INTERNATIONAL WATER SUPPLY CO.
DATE
Nov 16/68

DRILLERS LOG

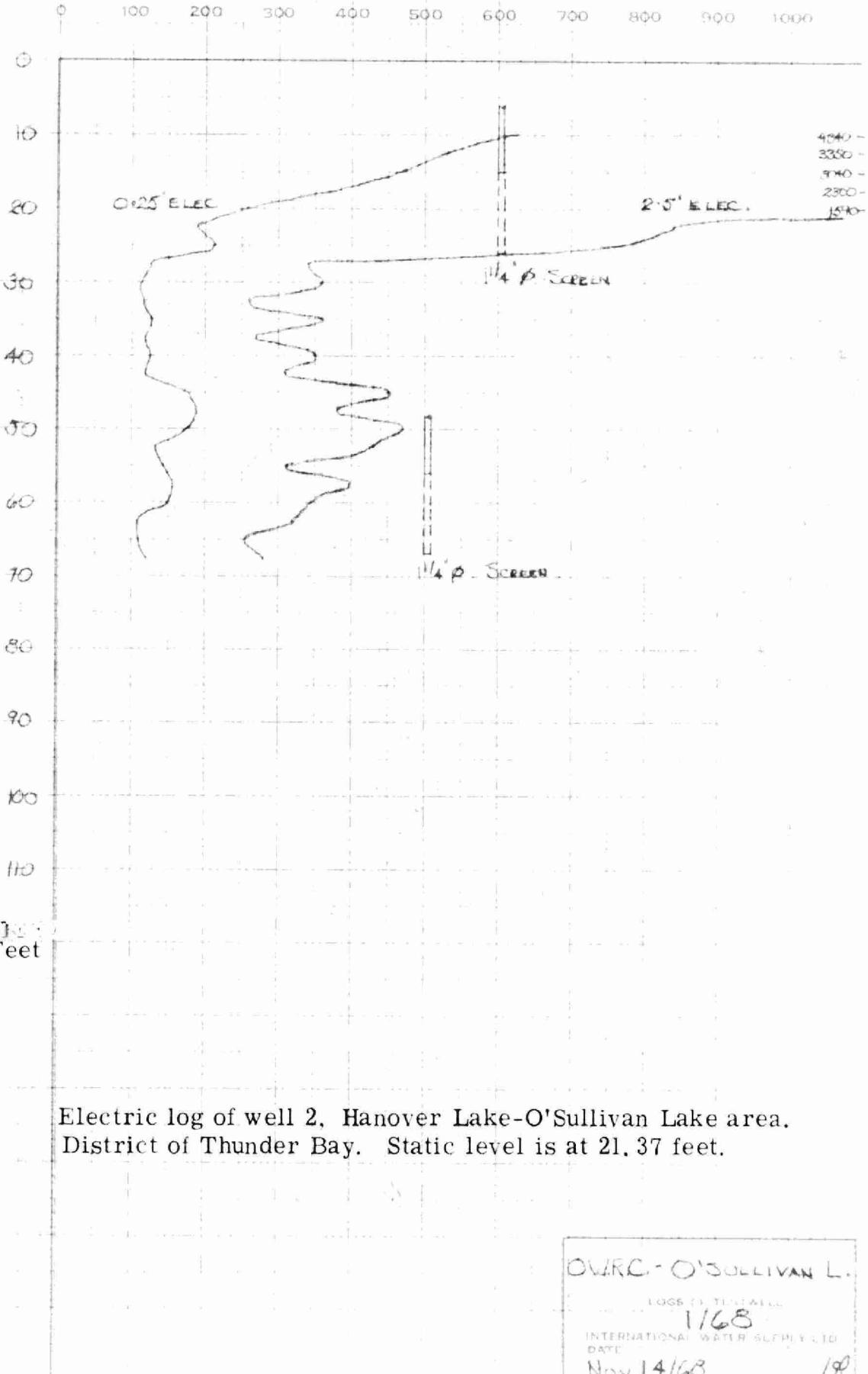
H. PETERMAN.

6' ROTARY.

ELECTRIC LOG

RESISTIVITY IN OHM-FEET

SAND	
CLAY	
SAND, GRVEL, CLAY, Boulders	
SAND, SILT	
CLAY, ODD Boulders	
CLAY, SILT STREAKS, ODD Boulders	
ROCK	
H2O	
Feet	



Appendix A.

Electric log of well 2, Hanover Lake-O'Sullivan Lake area.
District of Thunder Bay. Static level is at 21.37 feet.

OWRC - O'SULLIVAN L.
LOG NO. 1168
1168
INTERNATIONAL WATER SUPPLY LTD.
DATE
Nov 14/68

DRILLERS LOG

H. PETERMAN.

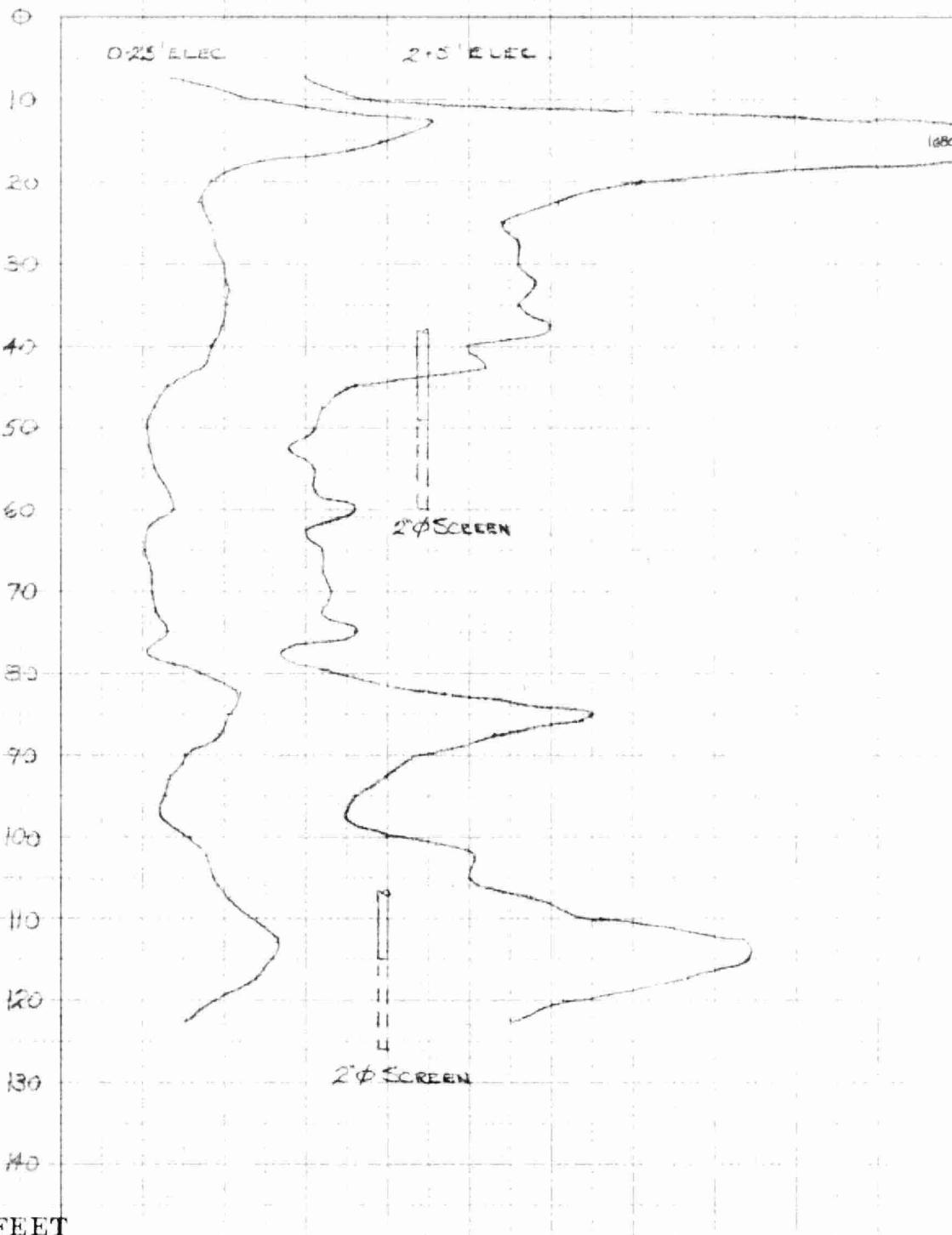
6" ROTARY

ELECTRIC - LOG

RESISTIVITY IN OHM-FEET

0 100 200 300 400 500 600 700 800 900 1000

DIRTY SAND.	10
BROWN CLAY	20
SILT	30
SILT, CLAY	40
	50
	60
CLAY, SILT	70
	80
	90
CLAY, GRAVEL	100
SAND, SILT.	110
ROCK	120
	130
	140
FEET	



Appendix A.

Electric log of well 3, Hanover Lake-O'Sullivan Lake area.
 District of Thunder Bay. Static level is at 31.36 feet.

ONRC - O'SULLIVAN L.

LOGS OF TESTWELL
 3/68
 INTERNATIONAL WATER SUPPLY LTD
 DATE
 NOV 20/68

AB

DRILLERS LOG

H. PETERMAN

6"φ ROTARY

6 PART SAND

FINE SAND.

COARSE SAND.

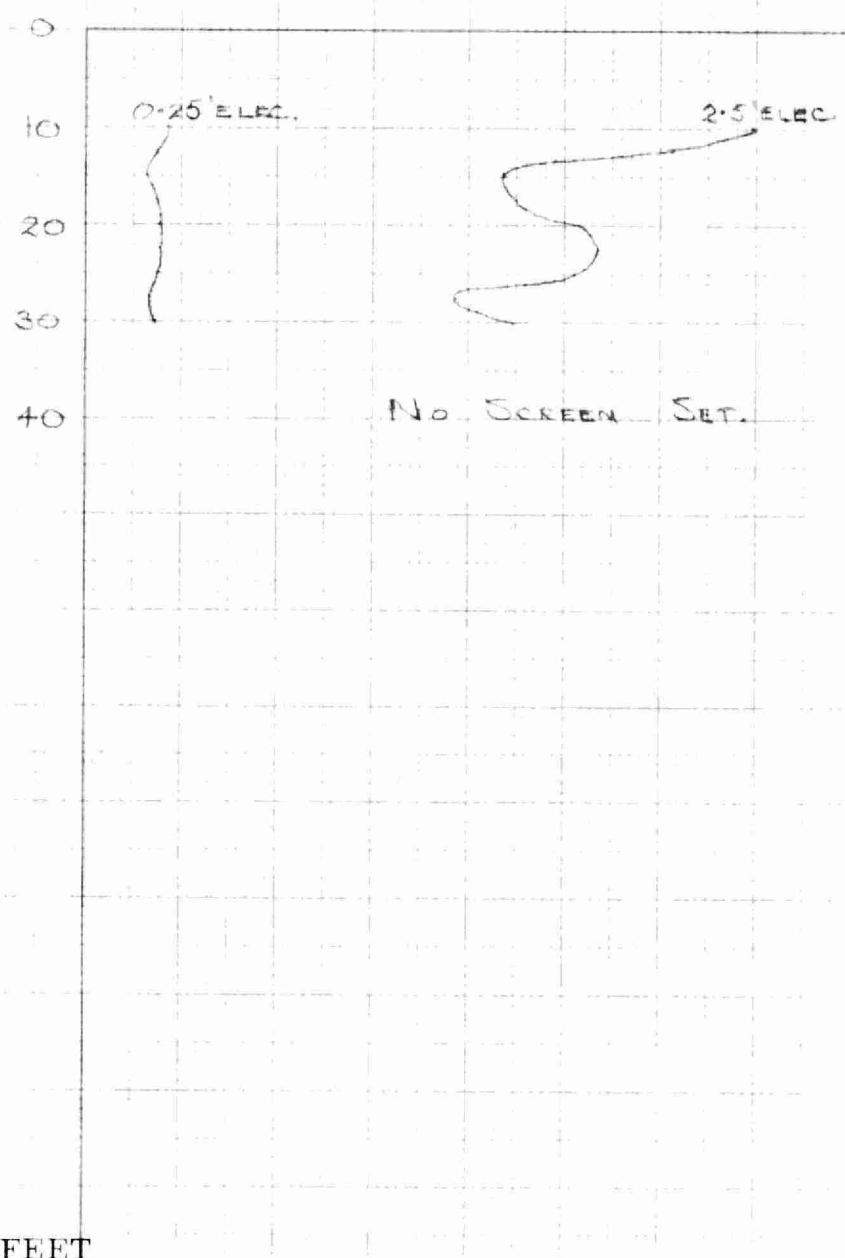
SAND
STREAKS OF FINE
GRAVEL

ROCK

ELECTRIC LOG

RESISTIVITY IN OHM-FEET

0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000



FEET

Appendix A.

Electric log of well 4, Hanover Lake-O'Sullivan Lake area, District of Thunder Bay. The well is dry.

OWRC - O'SULLIVAN LAKE
LOGS OF TEST WELL
468
INTERNATIONAL WATER SUPPLY LTD.
DATE
Nov 26 1968
16

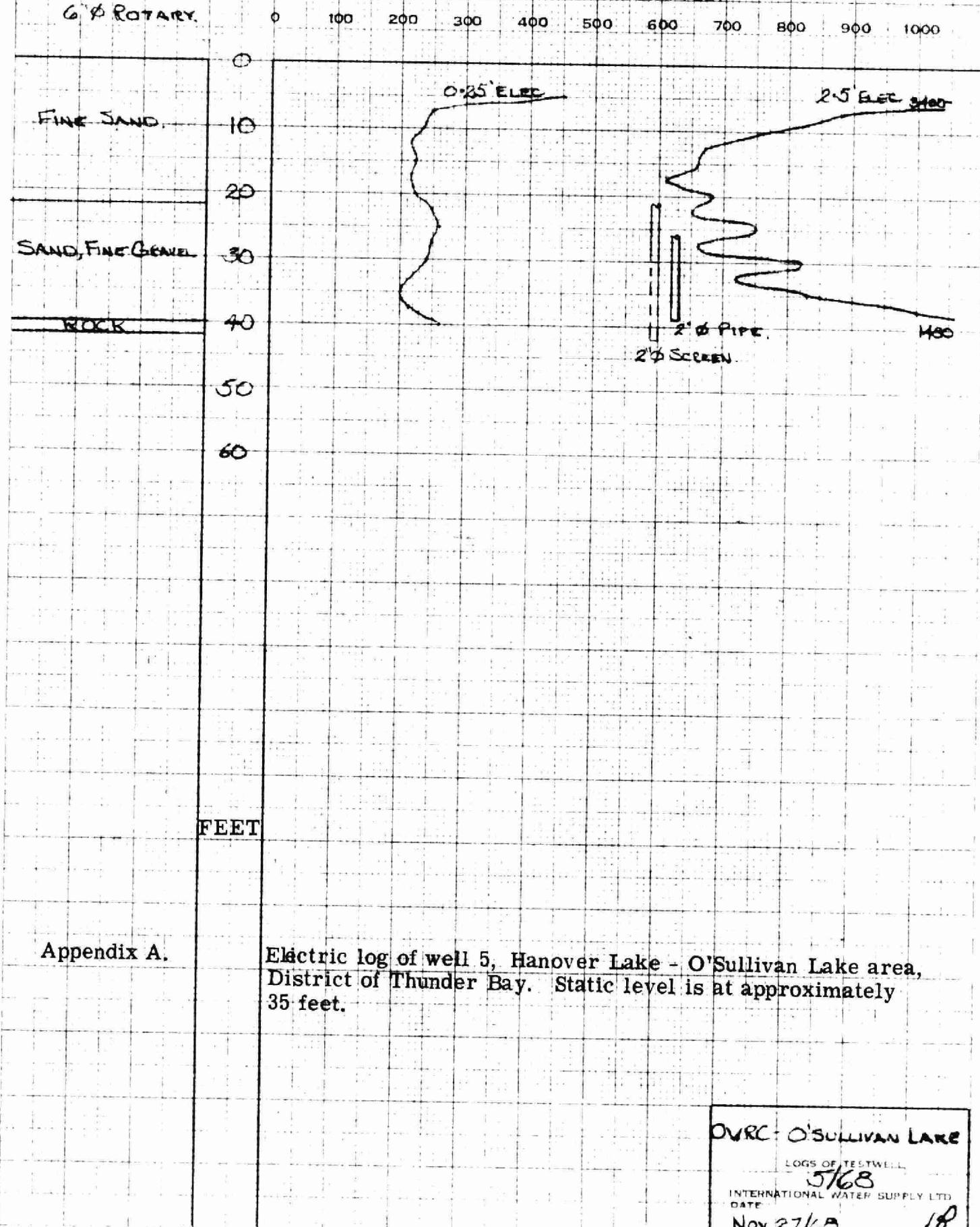
DRILLERS LOG

H. PETERMAN

6th ROTARY.

ELECTRIC - LOG

RESISTIVITY IN OHM-FEET



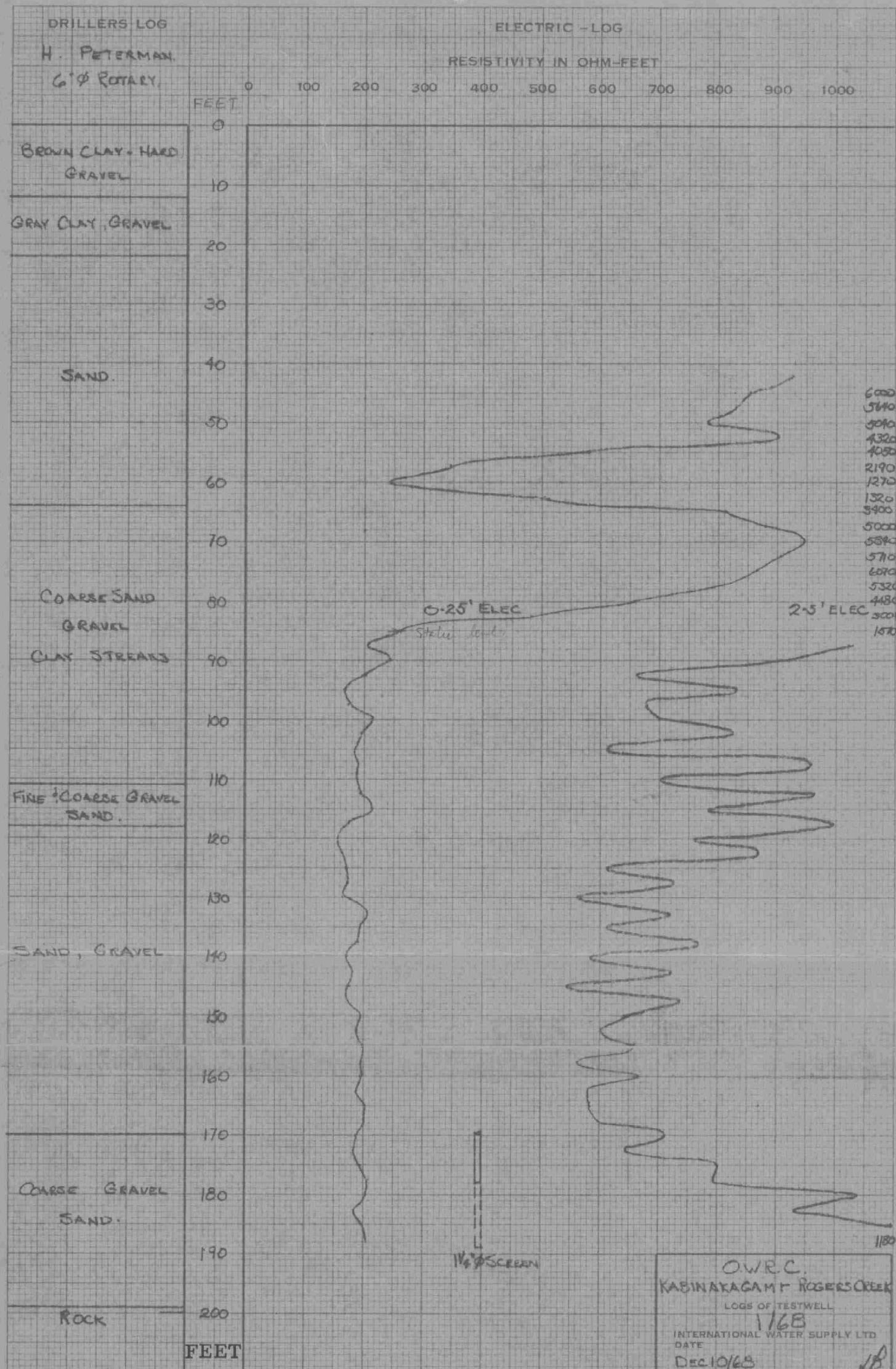
Appendix A.

Electric log of well 5, Hanover Lake - O'Sullivan Lake area, District of Thunder Bay. Static level is at approximately 35 feet.

DVRC - O'SULLIVAN LAKE
LOGS OF TESTWELL
5/68
INTERNATIONAL WATER SUPPLY LTD
DATE
Nov 27/68 (B)

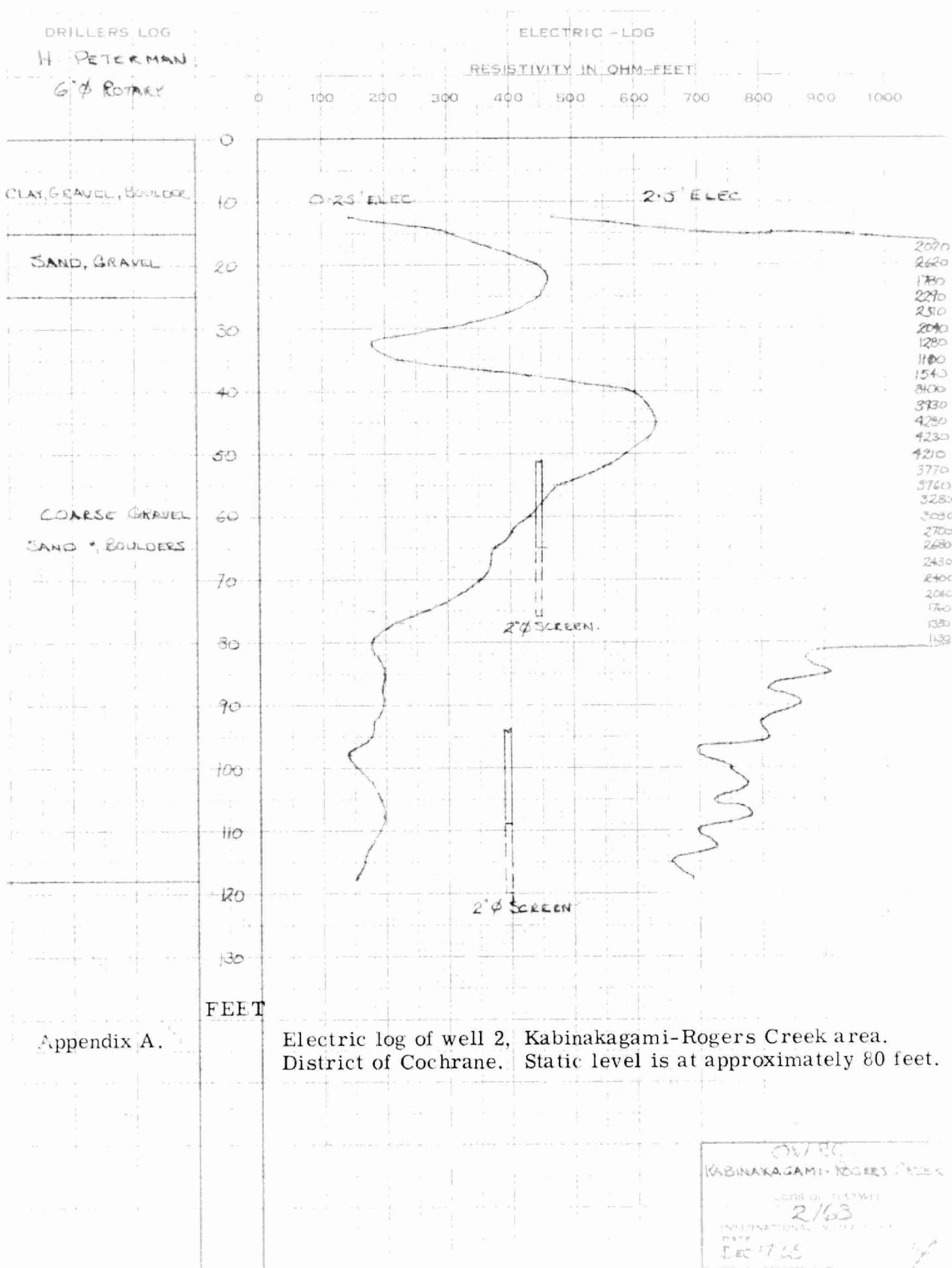
G9-12 G
10 x 10 TO THE 1/2 INCH
MADE IN CANADA

CCS
MICROGRAPH



Appendix A.

Electric log of well 1, Kabinakagami-Rogers Creek area.
District of Cochrane, Static level is at 84.57 feet.



Appendix A.

WR 3 - 68

ELECTRIC LOGS OF OBSERVATION WELLS

INTERNATIONAL WATER SUPPLY, LTD.

DATE NOV 16, 1968

ELECTRIC LOG

OFFICE

PROJECT W.K.C. WK3-68

DRILLER

H. P. Lehman

WELL 1

LOCATION DIST OF THUNDER BAY

SURFACE ELEV.

0.00

0.25' ELEC.		DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
RD'G	CORR.		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
		0			222	227	100	570	560	
		2.5			228		2.5	490		
		5			232		5	610		
121		7.5	180		215		7.5	1180		
164		10	330		217		10	610		
90		12.5	180		215		12.5	560		
90		15	260		217		15	640		
90		17.5	180		215		17.5	720		
150		20	300		310		20	970		
98		22.5	180		360		22.5	1240		
104		25	260		360		25	1020		
97		27.5	180		359		27.5	1030		
105		30	220				30			
117		32.5	130				32.5			
113		35	280				35			
106		37.5	220				37.5			
122		40	210				40			
153		42.5	220				42.5			
393		45	910				45			
237		47.5	810				47.5			
234	224	50	700	660			50			
219		52.5	500				52.5			
193		55	580				55			
173		57.5	400				57.5			
197		60	520				60			
183		62.5	370				62.5			
195		65	490				65			
190		67.5	420				67.5			
224		70	550				70			
211		72.5	490				72.5			
244		75	640				75			
223		77.5	520				77.5			
132		80	307				80			
118		82.5	230				82.5			
134		85	270				85			
116		87.5	220				87.5			
136		90	340				90			
158		92.5	320				92.5			
195		95	390				95			
189		97.5	440				97.5			

1M-S.Y.-6-66

PROJECT _____ WELL _____ DATE _____ COMPUTER _____ P.G. _____ OF _____

INTERNATIONAL WATER SUPPLY, LTD.

DATE Nov. 14/68

ELECTRIC LOG

PROJECT OWRE WP 3-68

OFFICE

DRILLER H. PETERMAN

WELL #2 LOCATION DIST OF THUNDER BAY

SURFACE ELEV.

0.25' ELEC.		DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
RD'G	CORR.		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
		0					0			
		2.5					2.5			
		5					5			
		7.5					7.5			
627		10	4340				10			
532		12.5	3350				12.5			
474		15	3040				15			
385		17.5	2300				17.5			
259		20	1590				20			
190		22.5	840				22.5			
213		25	770				25			
126		27.5	340				27.5			
116		30	360				30			
118		32.5	260				32.5			
128		35	360				35			
118		37.5	270				37.5			
125		40	350				40			
19		42.5	310				42.5			
172		45	450				45			
128		47.5	380				47.5			
178	178	50	440	470			50			
132		52.5	400				52.5			
143		55	290				55			
152		57.5	380				57.5			
149		60	330				60			
108		62.5	310				62.5			
110		65	250				65			
119		67.5	280				67.5			
		70					70			
		72.5					72.5			
		75					75			
		77.5					77.5			
		80					80			
		82.5					82.5			
		85					85			
		87.5					87.5			
		90					90			
		92.5					92.5			
		95					95			
		97.5					97.5			

1M-S.Y.-6-68

PROJECT _____ WELL _____ DATE _____ COMPUTER _____ P.G. _____ OF _____

INTERNATIONAL WATER SUPPLY, LTD.

DATE Nov 20/68

Well # 3

ELECTRIC LOG

PROJECT NabinaOFFICE #3-68WELL 3

LOCATION _____

DRILLER H Peterson

SURFACE ELEV. _____

0.25' ELEC.		DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
RD'G	CORR.		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
		0			158	162	100	360	400	
		2.5			178		2.5	470		
		5			187		5	470		
137		7.5	300		204		7.5	550		
240		10	380		240		10	640		
459		12.5	1000		268		12.5	820		
393		15	1680		259		15	830		
247		17.5	1100		234		17.5	760		
184		20	710		186		20	610		
172		22.5	610		152		22.5	550		
183		25	540				25			
190		27.5	560				27.5			
200		30	560				30			
204		32.5	580				32.5			
203		35	560				35			
198		37.5	600				37.5			
182		40	500				40			
176		42.5	520				42.5			
130		45	360				45			
117		47.5	320				47.5			
106	109	50	310	310			50			
109		52.5	280				52.5			
116		55	310				55			
130		57.5	310				57.5			
139		60	360				60			
103		62.5	300				62.5			
102		65	320				65			
110		67.5	320				67.5			
111		70	330				70			
114		72.5	320				72.5			
130		75	360				75			
104		77.5	270				77.5			
170		80	330				80			
220		82.5	470				82.5			
204		85	650				85			
191		87.5	530				87.5			
152		90	440				90			
132		92.5	400				92.5			
126		95	360				95			
121		97.5	330				97.5			

INTERNATIONAL WATER SUPPLY, LTD.

DATE Nov 26, 1968

ELECTRIC LOG

PROJECT WR 3-68

WELL 4 LOCATION DIST OF THUNDER BAY

OFFICE

DRILLER H. PETERMAN

SURFACE ELEV. 7

0.25' ELEC. RD'G	DEPTH CORR.	2.5' ELEC.		0.25' ELEC.		DEPTH RD'G	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
	0					0			
	2.5					2.5			
	5					5			
	7.5					7.5			
860	10	6980				10			
753	12.5	6140				12.5			
634	15	4380				15			
736	17.5	4500				17.5			
773	20	5180				20			
758	22.5	5380				22.5			
753	25	5110				25			
666	27.5	3880				27.5			
702	30	4470				30			
	32.5					32.5			
	35					35			
	37.5					37.5			
	40					40			
	42.5					42.5			
	45					45			
	47.5					47.5			
	50					50			
	52.5					52.5			
	55					55			
	57.5					57.5			
	60					60			
	62.5					62.5			
	65					65			
	67.5					67.5			
	70					70			
	72.5					72.5			
	75					75			
	77.5					77.5			
	80					80			
	82.5					82.5			
	85					85			
	87.5					87.5			
	90					90			
	92.5					92.5			
	95					95			
	97.5					97.5			

1M-S.Y.-6-66

PROJECT _____ WELL _____ DATE _____ COMPUTER _____ P.G. _____ OF _____

INTERNATIONAL WATER SUPPLY, LTD.

DATE NOVEMBER 27 1968

ELECTRIC LOG

OFFICE

DRILLER H. PETERMAN

WELL #5

LOCATION DIST. ON STATE HIGHWAY 541

SURFACE ELEV.

0.25' ELEC.		DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
RD'G	CORR.		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
		0					0			
		2.5					2.5			
452		5	3,100				5			
248		7.5	880				7.5			
235		10	770				10			
214		12.5	670				12.5			
221		15	660				15			
213		17.5	610				17.5			
222		20	680				20			
249		22.5	650				22.5			
260		25	750				25			
250		27.5	660				27.5			
240		30	820				30			
220		32.5	720				32.5			
200		35	830				35			
211		37.5	1000				37.5			
260		40	1480				40			
		42.5					42.5			
		45					45			
		47.5					47.5			
		50					50			
		52.5					52.5			
		55					55			
		57.5					57.5			
		60					60			
		62.5					62.5			
		65					65			
		67.5					67.5			
		70					70			
		72.5					72.5			
		75					75			
		77.5					77.5			
		80					80			
		82.5					82.5			
		85					85			
		87.5					87.5			
		90					90			
		92.5					92.5			
		95					95			
		97.5					97.5			

1M-S.Y.

PROJECT CWRC WR 3-68 WELL

DATE _____ COMPUTER _____ P.G. _____ OF _____

INTERNATIONAL WATER SUPPLY, LTD.

DATE Dec 10/68

ELECTRIC LOG

PROJECT

Forest #3-68 WR3-68

OFFICE

DRILLER HK Petersen

#1-68 WELL 1

LOCATION

DISTRICT OF COCHRANE

SURFACE ELEV.

0.25' ELEC.	DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION
		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
	0			213	211	100	630	700	
	2.5			197		2.5	760		
	5			188		5	550		
	7.5			190		7.5	900		
	10			190		10	650		
	12.5			192		12.5	910		
	15			213		15	740		
	17.5			175		17.5	930		
	20			157		20	720		
	22.5			164		22.5	830		
	25			170		25	580		
	27.5			172		27.5	690		
	30			163		30	540		
	32.5			204		32.5	690		
	35			194		35	590		
	37.5			191		37.5	750		
	40			174		40	570		
924	42.5			181		42.5	710		
855	45	6000		177		45	540		
830	47.5	5640		175		47.5	730		
384 783	50	5020	5040	195	189	150	700	640	
900	52.5	4320		190		52.5	650		
581	55	4050		199		55	710		
345	57.5	2190		195		57.5	610		
246	60	1220		193		60	710		
504	62.5	1320		189		62.5	620		
812	65	3400		203		65	620		
880	67.5	5000		201		67.5	630		
947	70	5840		186		70	740		
906	72.5	5710		183		72.5	670		
864	75	6070		197		75	820		
791	77.5	5320		209		77.5	810		
638	80	4480		207		80	1050		
443	82.5	3000		182		82.5	940		
261	85	1570		197		85	1100		
204	87.5	1020		204		87.5	1180		
246	90	820				90			
204	92.5	660				92.5			
166	95	830				95			
173	97.5	650				97.5			

1M-S.Y.

INTERNATIONAL WATER SUPPLY, LTD.

DATE 12/10/70

ELECTRIC LOG

OFFICE _____

PROJECT 2000-412-765

DRILLER _____

WELL 2

LOCATION DISTRICT OF COCHRANE

SURFACE ELEV. _____

0.25' ELEC.		DEPTH	2.5' ELEC.		0.25' ELEC.		DEPTH	2.5' ELEC.		DRILLERS LOG. FROM — TO FORMATION:
RD'G	CORR.		RD'G	CORR.	RD'G	CORR.		RD'G	CORR.	
		0			43	3	0	720	30	
		2.5					2.5	720		
		5			92		5	720		
		7.5			107		7.5	720		
		10			110		10	660		
		12.5			122		12.5	720		
		15			135		15	630		
		17.5			153		17.5	690		
		20					20			
		22.5					22.5			
		25					25			
		27.5					27.5			
		30					30			
		32.5					32.5			
		35					35			
		37.5					37.5			
		40					40			
		42.5					42.5			
		45					45			
		47.5					47.5			
		50					50			
5	52	52.5	5270				52.5			
5	55	55					55			
5	57.5	57.5					57.5			
5	60	60	6070				60			
5	62.5	62.5					62.5			
5	65	65					65			
5	67.5	67.5					67.5			
5	70	70	74				70			
5	72.5	72.5					72.5			
5	75	75					75			
5	77.5	77.5					77.5			
5	80	80					80			
5	82.5	82.5					82.5			
5	85	85					85			
5	87.5	87.5					87.5			
5	90	90					90			
5	92.5	92.5					92.5			
5	95	95					95			
5	97.5	97.5	9730				97.5			

1M-S.Y.

PROJECT _____ WELL _____ DATE _____ COMPUTER _____ P.G. _____ OF _____

OBSERVATION WELL INSTALLATION

Districts of Cochrane & Thunder Bay

APPENDIX B

(Geological Logs of Observation Wells)

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°21'	87°05'	junction of Anaconda Road and Kowkash Road, southeast of Hanover Lake, District of Thunder Bay.	43-05-001 (1)	0-3 3-52 52-79 79-97 97-103 103-112 112-128 128	Sand: Medium brown well sorted fine sand. Clay: Pale brown clay with scattered laminae of silt. Below 47 feet clay is hard packed, and semi-consolidated. Silt: Pale grey well sorted silt and very fine sand. Silt and Clay: Intercalated silt and clay. Silt and Clay: Compacted silt layers are intercalated with clay layers. Silt and Clay: Intercalated silt and clay with some silt layers compacted. Sandy Till: Pale grey sandy till with matrix of very fine sand. Bedrock: "Greenstone" forms end of hole.

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°21'	87°05'	junction of Anaconda Road and Kowkash Road, southeast of Hanover Lake, District of Thunder Bay.	43-05-001 (2)	0-8 8-13 13-17 17-25 25-67 67	Sand: Fine grained, medium brown, well sorted sand. Clay: Sand: Similar to 0-8 feet but with thin layers of pebbles intercalated in the sand. Sand and Silt: Very fine sand and silt with intercalated laminae of clay below 20 feet. Sand is concentrated in the upper portion of the increment. Clay: Pale grey plastic clay with thin beds of silt. Bedrock: Hole ends at the "greenstone" clay interface

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°20'	87°05'	junction of Anaconda Road and Kowkash Road, southeast of Hanover Lake, District of Thunder Bay.	43-05-001 (3)	0-3 3-15 15-40 40-44 44-109 109-117 117-126 126	Sand: Well sorted pale grey to medium brown to pale brown cross-bedded very fine grained and fine grained sand. Clay: Pale brown clay. Silt: Clayey-Silt/Silty-Clay: Pale grey to pale green-grey silty clay/clayey silt. Clay: Pale grey plastic clay. Till: Tills contains granules and pebbles, but the matrix is pale grey clayey sand/sandy clay. Till: Grey clayey sand forms the matrix of the till, but there is a preponderance of "greenstone" pebbles in it. Bedrock

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50° 25'	87° 08'	Anaconda Road, north of Hanover Lake, District of Thunder Bay.	43-05 002 (4)	0-16 16-24 24-30 30-30.5	Sand: Pale brown well sorted medium grained sand. Sand: Very coarse grained medium brown sand with granules and pebbles. Sand and Sandy Till: Upper part is predominantly sand but lower part is sandy till. Bedrock: Hole terminates 6 inches in the "greenstone" bedrock.

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°25'	87°08'	Anaconda Road north of Hanover Lake, District of Thunder Bay.	43-05-002	0-3 (5)	Till and Sand: The uppermost 6 inches is grey-brown sandy till. Below it is medium to coarse grained, poorly sorted sand, which grades downward into a zone with pebbles, cobbles and boulders.
				3-30	Sand: Pale grey, well sorted fine grained sand. Due to the difference in colour, grain size, and degree of sorting the contact between this layer and the overlying one is very conspicuous.
				30-41	Sand: Coarse grained and very coarse grained poorly sorted sand which is exceedingly loose such that the drill rods can penetrate it by their own weight without being rotated.
				41.41.6	Bedrock: Hole ends at 8 inches inside the "greenstone" bedrock.

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°01'	84°10'	18 miles north of Calstock, District 003 of Cochrane.	43-05- (1)	0-16	Clayey Till: Pale brown compacted clayey till with pebbles of limestone, mafic, and granitoid rocks. Pebbles of 1-2 inch diameter are most common but pebbles in excess of 6 inch diameter are uncommon.
				16-22	Clayey Till: Similar to 0-16 feet but medium grey in colour.
				22-85	Sand: Uppermost 10 feet is composed of medium brown, medium grained, poorly sorted sand. The sand is layered and varies from fine grained to very coarse grained. Few thin layers of granules and pebbles are intercalated in the sand, which also contain fragments of limestone and shells. Below 70 feet thin laminae of medium brown clay are present.
				85-110	Sand and Gravel: Intercalated very coarse grained sand and pebble gravel.
				110-118	Gravel: Fine pebble gravel grades downward into coarse pebble gravel.

OBSERVATION WELL LOGS
ALBANY RIVER BASIN

LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°01'	84°10'	18 miles north of Calstock, District of Cochrane.	43-05-003 (1) (con'd)	118-170 170-199 199	Sand and Gravel: Intercalated sand and pebble layers 2-3 feet thick. Pebbles are well rounded and are predominantly composed of limestone with minor jasper. Sand is very coarse grained. Gravel: Poorly sorted, well rounded fine to coarse pebble gravel with minor amounts of very coarse sand. Bedrock: Limestone.

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LOCATION			Well No.	Depth Below Surface (feet)	DESCRIPTION
Latitude North	Longitude West	Field Location			
50°01'	84°10'	18 miles north of Calstock, District of Cochrane.	43-05 003 (2)	0-15 15-25 25-33 33-120 120	Clayey Till: Pale brown compacted clayey till with pebbles of limestone, mafic, and granitoid rocks, and fragments of corals. Sand: Very coarse grained poorly sorted medium brown sand. Gravel: A very large pebble gravel. Sand and Gravel: Very coarse grained poorly sorted sand grades downward into sandy gravel. Gravel is a very coarse pebble to cobble gravel with very coarse sand. End of hole.